CONF-860102--1

LA-UR--85-3479

DE86 000796

OCT 09 1985

TITLE: PREDICTING NITRIDE FUEL PERFORMANCE FOR SP-100 CONDITIONS

AUTHOR(S): R. E. Baars, Q-12

SUBMITTED TO: To be presented at the Third Symposium on Space Nuclear Power Systems, on January 13-16, 1986, in Albuquerque, New Mexico.

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

FORM NO 836 R4
ST NO 2629 5/81

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

PREDICTING NITRIDE FUEL PERFORMANCE FOR SP-100 CONDITIONS

by

R. E. Baars
Los Alamos National Laboratory
Reactor Design and Analysis Group (Q-12)
Los Alamos, NM 87545
Commercial (505) 667-7897
FTS 843-7897

Introduction

This paper reports on the methods used to evaluate the performance of the nitride fuel design proposed for the SP-100 thermoelectric concept.

Thermoelectric Concept

The proposed thermoelectric fuel design was for 96% dense nitride fuel clad in 0.74 mm thick PWC-11 alloy (Nb-1%Zr-0.1%°C) with a 0.13 mm thick tungsten liner. The pin was to be operated at a peak cladding temperature of 1400 K, and was not vented. It would be operated at a peak power of about 13.4 kW/m to a peak burnup of 4.9 a/o. The pin diameter was 10.5 mm, with a 0.13 mm net radial gap between fuel and cladding. The pin was to be cooled by lithium.

Analytical Approach

No satisfactory code exists to analyze the performance of nitride fuel at this time. There is a LIFE-4C code,[1] but the nitride aspects of the code have long been neglected. We analyzed the proposed design manually using LIFE-4C as a heat transfer code along with correlations for fuel swelling and fission gas release proposed by Brian Harbourne of the General Electric Company. The fuel swelling correlation was developed by H. Zimmerman of the Nuclear Research Center Karlsruhe (KfK) and was modified slightly by Harbourne to better correlate nitride fuel data. The fission gas release correlation was developed by Harbourne and employs the fuel temperature gradient as the primary driving force causing pore velocity and fission gas release. These correlations are the subject of a paper authored by Harbourne in this symposium.

To analyze the proposed design, we first calculated fuel temperatures for contamination of plenum gas ranging from 0 to 100%, and for volumetric swelling ranging from 0 to 9% (gap closure expected at about 8.7% V/V). Charts were prepared showing mean fuel temperature as a function of fission gas contamination with swelling as a parameter. Calculating in increments of 0.5 a/o burnup, we would assume a fuel temperature and calculate the swelling and fission gas release over all axial segments. We then determined fuel temperatures for each node and compared these with the assumed temperatures. We repeated the process until agreement was obtained between assumed and determined temperatures at each burnup increment. Subsequently, we mechanized the procedure.

We analyzed the proposed design with this process for two cases--one case using the gas release correlation as originally proposed by Harbourne, and one case using a modified version of that correlation. The modified version used a fixed value of 5700 K/mm for the temperature gradient, a value at the high end of the data base. The modification was made to correct what we perceived to be a tendency to underpredict gas release as the correlation was originally proposed.

Results

Axial midplane average fuel temperatures for the two cases are shown in Figure 1 as a function of burnup. Other results were as follows. For the modified version of Harbourne's correlation for fission gas release, we predicted 33% release, and 1% creep strain for PWC-11 cladding because of plenum gas pressure loading. We predicted 1.9% cladding strain because of fuel swelling. For Harbourne's original gas release correlation, we predicted 5% release and negligible creep strain for either Nb-1%Zr or PWC-11 cladding because of plenum gas pressure loading. Cladding strain caused by fuel swelling was predicted to be 1.5%.

Conclusions

As a result of these analyses, we conclude that

1. An integrated fuel pin performance model is needed for nitride fuel pins,

2. Better understanding of fission gas release and swelling for nitride fuel is needed before detailed design of nitride fuel systems can proceed with confidence.

Acknowledgments

This work was performed at Los Alamos National Laboratory and was jointly sponsored by the US Department of Energy, the Department of Defense, and the National Aeronautics and Space Administration through the SP-100 Program Office. The counsel of W. Ranken of Los Alamos was invaluable.

References

1. Yung Y. Liu and U. P. Nayak (1981), "Verification of LIFE-4C, A Computer Code for (U, Pu)C Fuel Performance Modeling," ANS Trans. (39), San Francisco, California, pp. 420-421, 1981.

2. H. Zimmerman (1982), "Investigation of Swelling of U-Pu Mixed Carbide," J. Nuc. Mat. (105), pp. 56-61, 1982.

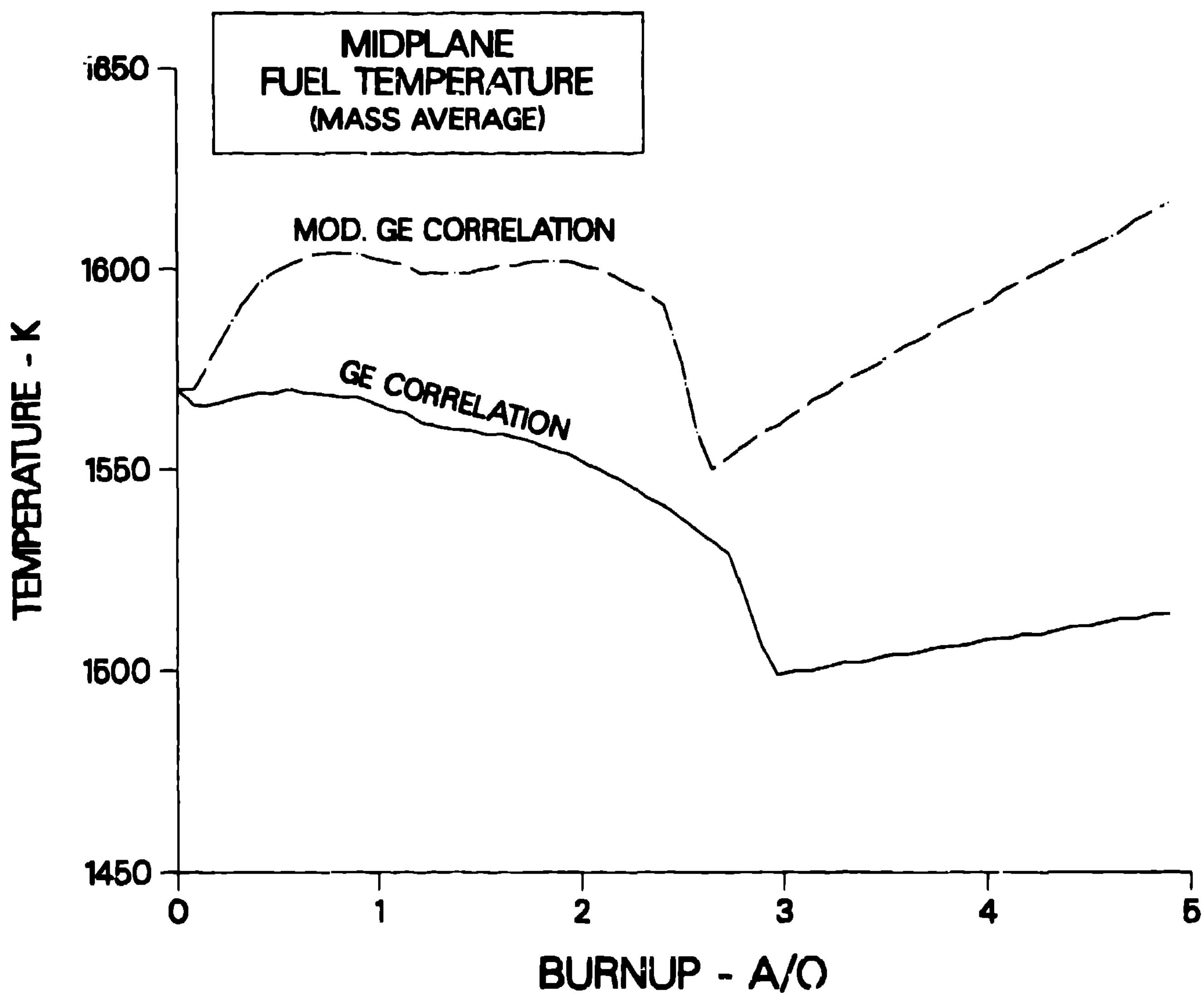

Figure 1. Mass averaged axial midplane fuel temperatures are shown for the peak powered thermoelectric nitride fuel element, both for the original fission gas release correlation provided by General Electric and for the correlation as it was modified.